The Omaha System: a systematic review of the recent literature

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ABSTRACT

Background The Omaha System (OS) is one of the oldest of the American Nurses Association recognized standardized terminologies describing and measuring the impact of healthcare services. This systematic review presents the state of science on the use of the OS in practice, research, and education.

Aims (1) To identify, describe and evaluate the publications on the OS between 2004 and 2011, (2) to identify major trends in the use of the OS in research, practice, and education, and (3) to suggest areas for future research.

Methods Systematic search in the largest online healthcare databases (PUBMED, CINAHL, Scopus, PsychINFO, Ovid) from 2004 to 2011. Methodological quality of the reviewed research studies was evaluated.

Results 56 publications on the OS were identified and analyzed. The methodological quality of the reviewed research studies was relatively high. Over time, publications’ focus shifted from describing clients’ problems toward outcomes research. There was an increasing application of advanced statistical methods and a significant portion of authors focused on classification and interoperability research. There was an increasing body of international literature on the OS. Little research focused on the theoretical aspects of the OS, the effective use of the OS in education, or cultural adaptations of the OS outside the USA.

Conclusions The OS has a high potential to provide meaningful and high quality information about complex healthcare services. Further research on the OS should focus on its applicability in healthcare education, theoretical underpinnings and international validity. Researchers analyzing the OS data should address how they attempted to mitigate the effects of missing data in analyzing their results and clearly present the limitations of their studies.

INTRODUCTION

For more than four decades, the Omaha System (OS) served healthcare providers in diverse settings as a standardized terminology for documentation of clinical information and to support healthcare research. First developed in the early 1970s by practitioners at the Visiting Nurse Association (VNA) of Omaha as a system for documentation and management of home care services, the applicability and validity of the OS increased steadily through the decades. Currently, the OS—one of the oldest of the American Nurses Association recognized nursing standardized terminologies—is widely applied across healthcare disciplines and settings in the USA and internationally.2

The aim of this paper is to report on a systematic review of the recent publications on the OS. A previous review on the topic was published 8 years ago.2 With the recent flurry of progress in electronic health records (EHRs) and informatics research, there is a critical need to identify the evidence that was published since then. Recent publications on the OS should be reviewed and analyzed to identify ways in which clinical data produced by nurses and other healthcare professionals might be meaningfully used from EHRs. Appropriate presentation of this information may enable healthcare providers, researchers, and other stakeholders to further understand how standardized EHR data may lead to improved quality of care and decreased costs.

BACKGROUND

Historic development of the OS

Early in the 1970s, the VNA of Omaha practitioners, managers, and administrators recognized the growing need to quantify professional healthcare practice. The VNA developed a vision of building a system that will use standardized terminology to describe and operationalize the nursing process. This vision and the combined efforts of the VNA and several academic institutions resulted in the creation of the OS. Between the 1970s and late 1990s, researchers, educators, and managers from diverse healthcare disciplines received several federal grants to further develop and expand the usefulness, validity, and reliability of the OS.3 Today, the OS is a comprehensive standardized terminology designed to generate comprehensive data for the description and evaluation of client care.

The OS structure

The OS model, originally based on the problem-solving approach proposed by Weed,4 includes three basic steps: problem–intervention–outcome.4 In the first step, also called the Problem Classification Scheme (PCS), healthcare practitioners collect assessment data, such as signs and symptoms, to identify patients’ problems and to formulate diagnoses. The PCS consists of four domains: environmental, psychological, physiological, and health-related behaviors. Forty-two problems are categorized under one of the four domains, and are identified by the signs and symptoms of the problem, the focus of the problem (individual, family, or community), and whether the problem is actual, potential, or encompasses the clients’ needs for health-promotion. During the second step, or the Intervention Scheme, the actual intervention is implemented by the provider. There are four intervention categories: health teaching, guidance, and counseling; treatments and procedures; case management; and surveillance. Specific nursing interventions are further delineated through the use of 75 targets (eg, ‘cardiac care’ or ‘dietary
management’). In the final step, Problem Rating Scale for Outcomes, the provider evaluates the care process by measuring its outcomes on a Likert scale in the area of knowledge, behavior, and status of each problem.1

Developers of the OS emphasized the importance of a multidisciplinary team approach and generated the standardized terminology to encompass terms used by diverse healthcare professionals. The OS is recognized by national organizations in the USA and integrated into the National Library of Medicine’s Unified Medical Language System (UMLS) Metathesaurus; Logical Observation Identifiers, Names, and Codes (LOINC); and Systematized Nomenclature of Medicine–Clinical Terms (SNOMED CT). The OS is available in the public domain at http://www.omahasystem.org.

Theoretical framework
Several theoretical frameworks influenced the development of the OS. First, the OS is rooted in the Donabedian healthcare quality model.5 According to this model, healthcare quality might be explained and evaluated by taking into consideration three aspects: (1) structure (characteristics of the care providers, their tools and resources, and the physical/organizational setting); (2) process (both interpersonal and technical aspects of the treatment process); and (3) outcome (change in the patient’s symptoms and functioning). The Neuman Systems Model is a nursing theoretical model that affected the development of the OS. According to this model, the nursing process might be represented by three consecutive steps: (1) nursing diagnosis, (2) nursing goals, and (3) nursing outcomes.6 Additionally, the OS structure supports the critical thinking process; it starts with seeking information and describing the existing situation, continues to the identification of the problem and intervention, and ends with the evaluation of the effectiveness of the applied steps.7,8

Aims
The goals of this systematic review on the OS were: (1) to identify, describe, and evaluate the publications on the OS between 2004 and 2011; (2) to identify major trends in the use of the OS in research, practice, and education; and (3) to suggest areas for future research.

METHODS
The previous literature review on the OS included articles published between the years 1983 and 2003. To build on this work and create a current state of the science, this review included articles published between 1 January 2004 and 31 December 2011. We decided to review articles published in English to enable a thorough understanding of the included manuscripts. To find the relevant literature, the keyword ‘OS’ was used to conduct a computerized search in the major biomedical and behavioral databases, namely PUBMED, CINAHL, Scopus, PsycINFO, and Ovid. The search was conducted with free text and used major terms, when applicable (eg, MeSH categories in PUBMED). Moreover, reference lists of the relevant articles and the OS website were reviewed to identify additional publications.

Articles were included in this review if they discussed, presented, or analyzed the OS and were written in English between 2004 and 2011. After being selected for the review, each article was read completely and then categorized to one of five categories independently by the two authors. The categories were compared and discussed until 100% agreement was reached.

Categories
In the previous review on the OS, Bowles2 used eight categories to classify the existing literature. In the present review, these categories were revised to better represent the scope of the recent publications. Relevant articles were classified to one of the five categories based on the article’s purpose: (1) analyze client problems; (2) analyze clinical process; (3) analyze client outcomes; (4) advance classification research; and (5) other. Four categories presented in the previous review—namely, ‘explain healthcare resource utilization’, ‘involve students’, ‘report on the Community Nurse Organization project’, and ‘report on unpublished Master’s and Doctoral dissertations’—were collapsed into a new category ‘other’ because of the low numbers of these types of publications. Also, the ‘other’ category included non-research publications on the OS describing how the OS might be applied in healthcare practice and research. Finally, one category was renamed to better represent the included literature, namely ‘describe clinical practice’ was changed to ‘analyze clinical process’.

One example that illustrates the current categorization process is an article titled ‘Family home visiting outcomes for mothers with and without intellectual disabilities’,9 which was categorized as ‘analyze client outcomes’ because its main goal was to evaluate the impact of homecare nursing interventions on mothers’ outcomes. Another example is a non-research article titled ‘The OS: coded data that describe patient care’ that was categorized as ‘other’ because its main goal was to describe the structure, aims, and capabilities of the OS for the use by healthcare professionals.10

Methodological quality evaluation
For research manuscripts reporting results of experimental, quasi-experimental, and observational studies, we evaluated the methodological quality using three validated and widely applied tools:

1. Consolidated Standards of Reporting Trials (CONSORT) criteria11 for randomized controlled trials. CONSORT checklist includes 25 items evaluating the content of the title, abstract, introduction, methods, results, discussion, and other information presented in clinical trials. To construct a methodological quality index, each of the 25 items was given a score of one point if it was fully addressed; half a point if it was partially addressed; and zero points if it was not addressed. For example, the article was given one point if a table showing baseline demographic and clinical characteristics for each group was present in the study Results section (item 15 in the CONSORT checklist11).

2. Downs and Black’s checklist for non-randomized studies.12 Downs and Black’s checklist consists of 27 items that relate to the methods and findings of non-randomized studies. To construct a methodological quality index, each of the 27 items was given a score of one point if it was fully addressed; half a point if it was partially addressed; and zero points if it was not addressed. For example, the article was given one point if the characteristics of patients lost to follow-up were fully described (item 9 in Downs and Black’s checklist12).

3. Strengthening the Reporting of Observational studies in Epidemiology (STROBE) criteria13 for observational analytical studies. The STROBE statement consists of a checklist of 22 items, which relate to the title, abstract, introduction, methods, results, and discussion sections of articles. To construct a methodological quality index, each of the 22 items14 was given a score of one point if it was fully addressed; half
a point if it was partially addressed; and zero points if it was not addressed. For example, the article was given one point if specific objectives, including any prespecified hypotheses, were fully addressed in the Objectives or Background sections (item 3 in the STROBE checklist14).

Since there is a lack of accepted standardized tools to evaluate the methodological quality of descriptive studies, we modified the STROBE checklist14 to exclude items that were not applicable to descriptive studies. For example, the case–control study specific item (item #6) of the original STROBE checklist, ‘Give the eligibility criteria, and the sources and methods of case ascertainment and control selection and give the rationale for the choice of cases and controls’ was removed since it is not applicable to descriptive studies. Overall, five items of the original STROBE checklist were removed (items 7, 11, 15–17); the final modified STROBE checklist included 17 items. To construct a methodological quality index, each of the 17 items was given a score of one point if it was fully addressed; half a point if it was partially addressed; and zero points if it was not addressed. Higher score indicated higher methodological quality of the reviewed article.

Since some of the included articles were authored by the second author of this review, to avoid conflict of interest, we invited an additional reviewer to validate the methodological quality evaluation. Methodological quality evaluation was performed by the first author and the second reviewer independently. Disagreements were discussed and 100% agreement was achieved on the methodological quality checklists.

RESULTS

Figure 1 presents the search strategy and results. Overall, 195 articles were found in major biomedical and nursing literature databases using the key words ‘OS’. An additional 18 publications were identified using the articles’ reference lists and the OS website’s publications list. Non-duplicated references (n=86) were then hand searched and relevant articles were identified based on the inclusion criteria presented in the methods section. The total number of publications included in this review is 56. Figure 2 represents the time-trends in scientific publications on the OS. It is evident that, in general, the number of publications is increasing over time: the previous review on the use of the OS2 conducted in 2004, included 41 publications over the time period of more than two decades (1982–2003), while this review identified 56 relevant publications over the last 7 years. This is a more than four-fold increase in the average number of articles per year. Moreover, the number of publications grew steadily through the last years, peaking with 16 articles published in 2011.

Figure 1 presents the percentage of articles in each of the five primary categories. As reflected in figure 1, about one third of the publications focused on the analysis of client outcomes (29%). One-fifth of the identified literature analyzed either client problems (13%) or clinical process (9%). Another 21% of the articles were focused on advancing the classification research. The rest of the literature (29%) was categorized as ‘other’ and included literature reviews, practical guidelines on the applications of the OS in community settings, and publications reflecting the importance and growing need for application of standardized terminologies in clinical practice. Table 1 presents the number of articles in each category.

Figure 3 depicts the change in focus of research literature. Over the years, there was an increasing number of articles published that either analyzed client outcomes or advanced classification research. On the other hand, the number of articles that focused on the analysis of clinical processes or the analysis or client problems remained low or decreased during the presented time period.

Additional trends were captured by a detailed article analysis. For example, the first studies that applied data mining techniques to analyze OS data were published in 2008.37 Since then, the use of data and text mining (or machine learning) has steadily grown.28 29 34 37 47 Also, the number of articles focused on patients’ outcomes increased significantly. On the other hand, the number of research projects that involved students remained stable during 2004 to 2006, but since 2007 no publications related to this category were identified.20 40 41 43 64 67 There is significant growth in the number of studies conducted by international authors (N=9, 17% of total number of articles).19 21 23 24 31 35 36 43 46 Additionally, four studies were focused on the interoperability between the electronic records in different settings.42 44 46 49

Four articles were authored by non-nurses (first author),46 48 51 53 while several others (especially studies conducted by the ‘OS Partnership for Knowledge Discovery and Health Care Quality’ at the University of Minnesota) included interdisciplinary co-authors. Most of the papers authored by non-nurses focused on classification research. Only one study was conducted in inpatient settings (medical-surgical unit).55 Finally, seven studies explicitly reported that they used OS coded data from EHRs.23 25 29 30 34 37 38

Methodological quality evaluation

Online supplementary table II presents a short description of the included articles by category. Forty (71%) of the reviewed articles were research studies, however the study designs and methodological approaches varied significantly.

One randomized controlled trial was identified35; its quality was relatively high (21/25 points using the CONSORT11 checklist). We identified one quasi-experimental study31 (non-randomized one-group pre-test and post-test); its methodological quality was intermediate (22.5/27 points using Downs and Black’s checklist15). Seven observational studies used correlational design (six of them were in the ‘Analyze client outcomes’ category).28 30 37 38 52 The overall methodological quality of these articles was relatively high; using the STROBE criteria, the average score was 18/22 (range 17–20). The most common issue was the lack of reporting on what was done to mitigate the effects of missing data (items 12 and 14 in the STROBE checklist). Finally, 31 studies used descriptive design.55 26 32–34 36 39–44 46–48 50 51 53 64 67

The overall methodological quality of these articles was also relatively high; using the modified STROBE criteria, the average score was 14.6/17 (range 12–16.5). The most common issues were the lack of description of the efforts to address potential sources of bias and insufficient or lacking discussion of the limitations of the study (items 9 and 19 in the original STROBE checklist14).

Methodological quality scores are presented in online supplementary table II, when relevant.

DISCUSSION

Improving the quality of healthcare and enhancing meaningful use of novel information technologies are complex tasks that require interdisciplinary collaboration of researchers, educators, practitioners, and other stakeholders. This systematic review aimed to describe and analyze recent literature to identify trends and patterns of a scientific inquiry on the OS, one the most frequently used standardized terminologies for the documentation and provision of community healthcare services.
The results of this review indicate that, in general, there is an increasingly growing body of literature on the OS; there is a more than fourfold increase in the average number of articles published each year compared with a previous systematic review on the topic. According to the OS website http://www.omahasystem.org, there are currently more than 9000 multidisciplinary practitioners, educators, and researchers using the OS in point-of-care software in the USA and other countries. As shown in figure 2, publications on the OS describe and explain a wide range of healthcare phenomena. About half of the publications on the OS were focused on the analysis of client outcomes (29%), clinical processes (9%), or client problems (13%).

The presentation of the number of articles by primary category (figure 3) on the timescale identified an interesting transition: the number of articles that analyzed client outcomes increased over time, whereas the number of articles analyzing client problems gradually decreased over the last 8 years. This shift was predicted in the previous review on the OS and might...
Although the number of articles that primarily focused on the analysis of clinical process remained low during the presented time period, the application of novel statistical methods (such as data mining) enabled OS researchers to start exploring the complex interplay between patient characteristics, clinical process, and outcomes. For example, Monsen et al. compared deductive and inductive approaches to group nursing interventions in a homecare setting. Deductive approaches included several conventional methods (such as clinical expert consensus, an approach in which clinical expertise guides the identification of meaningful intervention groups) while the inductive approach was based on data mining. Application of the data mining methods helped researchers to group co-occurring interventions inductively based on the existing data. After analyzing a large computerized dataset that included OS data on 2862 patients from 15 homecare agencies, Monsen et al. concluded that compared to the deductive approaches, the ‘approach based on data mining generated more intervention groups that represented nursing care provided to complex homecare patients’. Afterwards, Monsen et al. used these intervention grouping approaches to explain hospitalization outcomes for frail and non-frail elders. These examples illustrate novel methodological ways in which OS data might be meaningfully used for the identification of client and process characteristics leading to specific outcomes. More research is needed to explore further opportunities using novel and standard statistical methods to analyze large databases from EHRs.

Classification research on the OS is an additional constantly growing field of research. Classification research is necessary to enhance the validity and applicability, and further develop the OS and integrate it into diverse national and international healthcare environments. The findings of this review indicate that there is a growing body of literature on how to further enhance the semantic structure\(^1\) and other aspects of the OS.\(^{42} 45 47–49\) Recommendations suggested by these researchers should guide the future revision of the OS and might serve as a lens to examine other standardized terminologies. Additionally, researchers should pay more attention to translational research that aims to understand the implementation of healthcare research and novel technologies into clinical practice. For example, this review identified no studies on integration of decision support tools based on the OS or OS based EHRs usability testing.

With only few exceptions, most of the publications identified in this review were published on nursing topics and by nurses. Recently, there has been an emerging trend of interdisciplinary collaboration when performing research on the OS. The results of this work are highly important as they produce a platform for healthcare researchers and practitioners to apply diverse research methods or to use different epistemological and philosophical approaches when understanding healthcare services. One example is an interdisciplinary team of researchers based at the University of Minnesota School of Nursing. This group, called ‘OS Partnership for Knowledge Discovery and Health Care Quality’, consists of a diverse group of researchers from nursing, medicine, computer science, and biostatistics. Although relatively new, the group produced a large bulk of recent publications on the OS.\(^{26} 30 33 34 50–52\) More interdisciplinary partnerships like this are needed to further develop the potential of the OS.

The OS can be further developed to meet the needs of diverse clients in different healthcare environments. For example, even though there is evidence of application of the OS in clinical settings other than community and public health,\(^72\) this review identified only one publication\(^{53}\) describing OS data in acute care settings. This lacking evidence is critical to further

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**Table 1 Publications on the Omaha System (OS) by category**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of publications</th>
</tr>
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<tbody>
<tr>
<td>Analyze client problems</td>
<td>7(^1)–21</td>
</tr>
<tr>
<td>Analyze clinical process</td>
<td>5(^2)–26</td>
</tr>
<tr>
<td>Analyze client outcomes</td>
<td>16(^3)–27–41</td>
</tr>
<tr>
<td>Advance classification research</td>
<td>12(^4)–53</td>
</tr>
<tr>
<td>Other</td>
<td>16(^5)–54–68</td>
</tr>
</tbody>
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**Figure 3** Time-trends in articles’ focus.
advance the meaningful use of standardized terminologies. Furthermore, the most recent report by the National Academies of Science and Agency for Healthcare Research and Quality suggested ways to improve care provided in people’s homes by formal and informal caregivers (such as family members). The authors of the report recognized the critical need for research on how health outcomes of homecare patients related to the home environment (especially physical) and different parameters of the informal caregivers (such as the level of stress).

This area of research is particularly suitable for the OS researchers because of the focus on home and outpatient environments, but more tools addressing those issues should be developed, validated, and incorporated into the OS. Also, as suggested in the previous OS review, the OS might incorporate data that can lead to understanding healthcare expenditures and service costs. This review identified only limited evidence on the development of additional scales/measures/tools that might be incorporated into future revisions of the OS.

The OS is rooted in several theoretical models and might even be considered as an independent conceptual model. Some suggest that in order to explain new phenomena and evidence, theoretical frameworks should be frequently reexamined and, if needed, revised. With a growing body of critique of the models that underpin the OS, some of the relations and assumptions underlying the OS should be reevaluated. For example, several authors find difficulties in relating outcomes directly to services and critique the Donabedian framework of structure-process-outcomes (which is one of the theoretical models the OS is rooted in) for its over-simplistic representation of the quality of healthcare. Presentation of the structure-process-outcomes model in a linear fashion might mis-specify the actual linkages between components of quality that serve as mediators or moderators in the healthcare delivery process. Unfortunately, no publications evaluating the theoretical framework of OS were identified in the presented time period.

The OS can be used to structure and analyze the outcomes of nursing education, as presented by Elfrink and Davis, who used the OS data to understand the educational needs and progress of their students. Although others also addressed the use of the OS by students, this review identified no articles on the topic since 2007. As informatics became one of the core competencies that healthcare graduates should have, the absence of evidence about the effective educational approaches might hinder the production of comprehensive data from EHRs or even decrease the quality of the care provided. Also, some researchers reported that nurses working with EHRs based on the OS did not use it appropriately and produced large amounts of missing data and duplicate entries. Unfortunately, very little evidence was identified about what type of education is effective for the users of the OS in real settings. Lack of research in this critical field might hinder the ability of the next generation of healthcare specialists to provide appropriate care and meaningfully use the existing systems.

The OS system has a long history of international adoption and implementation. This review identified a significant number of articles (17% of the total number of publications) written by researchers from China, Italy, South Korea, and Turkey. These publications represent the adoption of the OS in a global and interdependent world. The trends in publications of international researchers are similar to the general trends presented previously in this review: over time, there is a shift from describing clients’ problems toward outcomes research. Surprisingly, although a significant number of international healthcare providers apply the OS, very little evidence exists on cultural and population tailoring and validation of the OS, even though it was created and tested in the USA. The issue of cultural appropriateness is highly important because the healthcare systems and their clients in other countries might have different sets of problems than those that the OS addresses. For example, Taiwanese authors indicated that because ‘...health concepts of most of Taiwan’s older people are rooted in traditional Chinese medicine... Omaha Classification Scheme is less relevant to their health needs’. Other standardized terminologies started to develop processes of cultural adaptation. For example, Taiwanese researchers have recently described how they used a modified Delphi strategy (using forward translation and expert consensus) to facilitate semantic and cultural translation and validation of the International Classification for Nursing Practice (ICNP). This suggests that more research is needed to effectively translate and validate the concepts of the OS in other countries.

Finally, this review identified a growing body of literature that indicates the applicability of the OS in healthcare settings among diverse populations. For example, OS data were used to describe and analyze the problems and outcomes of elderly persons with and without cognitive impairment in homecare and hospices, pregnant and postpartum women, teenagers and toddlers. Moreover, the OS was applicable to represent and understand the needs of ethnic minorities, such as Latinos and Native Americans. Further research based on the OS should address healthcare disparities and might be used to represent the needs and voices of other underprivileged populations.

The results of this review suggest that further research is needed in the following areas:

- **Education**: (1) Describe, understand, and identify the effective applications of the OS in healthcare education. (2) Find effective educational approaches for ongoing instruction of healthcare providers that use the OS in practice.
- **International users**: (1) Validate the cultural appropriateness of the OS outside the USA. (2) Conduct international studies using the OS data to compare and analyze health outcomes.
- **Theoretical framework**: (1) Examine and revise, if necessary, theoretical frameworks that underpin the OS. (2) Examine the possibility of including new theoretical models to expand the ability of the OS to describe and explain new healthcare phenomena (eg, outcomes combined with healthcare costs).
- **Classification research**: (1) Examine the need and develop, if necessary, additional scales/measures/tools that might be incorporated into future revisions of the OS (eg, evidence based decision support tools at the point of care). (2) Increase the interoperability of the OS between clinical settings, providers, and other medical terminologies.
- **Other**: (1) Understand factors affecting successful implementation of the OS in real settings (such as organizational and provider characteristics). (2) Analyze the applicability and validity of the OS to represent data needed for comparative effectiveness research, patient-centered outcomes research, and medical home research.

**Limitations**

Although the search for publications was performed in the largest healthcare databases, it is possible that some of the literature sources were not identified. Furthermore, all the reviewed literature was written in English and publications in other languages were not included. The modified STROBE checklist for methodological quality evaluation was not used or validated in previous studies. We did not evaluate the methodological
quality of some of the presented articles since not all the publications presented results of primary research. Also, this review is focused on the OS and conducting comparisons with other standardized terminologies is beyond the scope of this review. Lastly, some of the trends presented in this review might be misidentified because of personal or publication bias.

CONCLUSION
With the rapid advancements in technology, healthcare systems in the developed and developing countries rely more and more on EHRs to store and analyze clinical data. Therefore, there is a critical need to understand how standardized terminologies might be meaningfully adopted and used in healthcare settings. This systematic review focused on the OS, one of the oldest and most widely used standardized terminologies in community-based care, and identified recent trends that advance its meaningful application in the USA and internationally.

In this review, we presented the most recent ways in which the OS provides comprehensive and high quality information about complex healthcare systems and services, especially when incorporated into EHRs. Analysis of this information has a proven potential to advance our understanding of clinical processes leading to health outcomes in diverse populations. Moreover, the example of the OS illustrates that applying standardized terminologies helps nurses and other healthcare professionals to better represent the impact of their care and further enhances the understanding of their clients’ needs. Due to the non-proprietary nature of the OS, it may be used free of charge by the global healthcare community. Further research on the OS should focus on its applicability in healthcare education, theoretical underpinnings, and international validity. Researchers analyzing the OS data should pay more attention to addressing the nature and the quality of missing data in their publications and clearly present the limitations of their studies.

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Contributors MT and KHB designed the methods, examined the findings, interpreted the results, and wrote the paper. MT and NG carried out the methodological quality evaluation. All authors have attributed to, seen, and approved the manuscript.

Competing interests KHBauthored several manuscripts included in this review; she did not evaluate the methodological quality of the literature and an additional reviewer was invited.

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